Fermilab

TM-847
2966

N7/N5 LINE MODIFICATIONS

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INTRODUCTION

Recently, the N7 and N5 lines in the Neutrino area were upgraded to provide a new beam[1] with more acceptance than the initial design[2]. This original beam was built to provide a low intensity flux for the 15 foot bubble chamber - it had an acceptance of 0.3 μstr %. The recent upgrade increased this number to about 2.7 μstr %. With the forthcoming installation of the Tevatron shield[3] this summer, however, further modifications of this line must be made in order to maintain the integrity of the shield. This report summarizes the results of a design which matches the upgraded beam in performance and, in addition, minimizes interference with the shield.

GEOMETRIC AND MONETARY CONSTRAINTS

The Tevatron shield is envisioned to be a 6' radius steel rod centered on the NØ beam line (X = -0.667') extending from the downstream end of E-1ØØ to the vicinity of Batavia Road. For this report, a design goal was to have no magnetic elements inside this shield area and in addition to minimize the amount of beam pipe inside. This pipe must be replaced by steel plugs[4] during Tevatron neutrino operation. Consequently, the upstream end of E-1Ø1 (the closest point of approach to the steel) was fixed at 6' from NØ plus 3' for walls, space and pipe to total a lateral position of X = -9.667'. This implied about a 25 mr bend

References

1. J. Ritchie, "Report on a Design Study for Upgrading the N7/N5 Hadron Beamline", TM-805.

2. J. Lach and S. Pruss, "Hadron Beams in the Neutrino Area", TM-285.

3. S. Mori, "Muon Shield for the Tevatron at Fermilab", TM-285.

4. W. Nestander, private communication.

in E-1ØØ. Once this figure was established, it became necessary to move the target to E-1Ø1 as there was no longer enough room in E-1ØØ for pre-target quadrupoles and the 80' of bending magnets necessary for the 25 mr bend. (Conservative studies indicate the spot size on this E-1Ø1 target should be <u>better</u> than a few millimeters full width.)

In order to minimize cost, it was decided to match into the existing N5 beam line from E-1Ø5 on down. This implied a west bend in the re-located E-1Ø1 of 11.4 mr and an east bend in E-1Ø3 of 13.2 mr. Enough bending magnets in 1Ø3 were inserted so that one could also match into the N3 beam line which services the 30" bubble chamber.

With bend points fixed, quadropoles were added to E-1Ø1 and E-1Ø3 to provide a solid angle acceptance comparable to the existing beam. (Figures 1 and 2). For monetary reasons, a further constraint was imposed such that no further changes were made from E-1Ø5 to E-113. In addition, (as does the existing beam) the new design achieves quite small beam divergence from E-1Ø9 to E-113, the region containing Cherenkov counters (Figure 3). Principal ray traces are shown in Figure 4.

For increased flexibility in selecting secondary particle fluxes, targetting angle magnets have been included in E-1Ø1.

Figures 5, 6 and 7 are detailed drawings of the proposed magnet arrangements for E-1ØØ, E-1Ø1 and E-1Ø3, respectively. Table I lists the exact placement of all devices.

Table II gives the new bend points and the currents necessary for 4ØØ GeV operation of this design. Table III details quadrupole parameters.

<u>CONCLUSION</u>

Because of the Tevatron shield installation, the N7/N5 beam line must be moved to the east near E-1Ø1. A new design to accommodate this shift has been proposed which matches the existing beam in acceptance.

TABLE I

N7/N5 MODIFICATIONS FOR E1ØØ, E1Ø1, E1Ø3

Element	Position Code	Z(FT) Cent	X(FT) Cent
E-100 Wall	-	4816.Ø	-1.886
Profile Wire Chamber	7WCØØ-1	4821.Ø	-1.886
Profile Wire Chamber	7WCØØ-2	493Ø.5	-1.886
3Q12Ø Quad	7DØØ	494Ø.5	-1.886
5-1.5-24Ø Bend	7EØØ-1	4957.Ø	-1.9Ø16
5-1.5-24Ø Bend	7EØØ-2	4978.5	-2.Ø362
5-1.5-24Ø Bend	7EØØ-3	5ØØØ.Ø	-2.3Ø54
5-1.5-24Ø Bend	7EØØ-4	5Ø21.5	-2.7Ø91
3Q12Ø Quad	7 FØØ	5Ø38.Ø	-3.1Ø67
4-4-3Ø Vert. Vernier	7VØØ	5Ø46.Ø	-3.3Ø7Ø
Profile Wire Chamber	7WCØØ-3	5Ø49.Ø	-3.3821
E-1ØØ Wall	-	5Ø52.Ø	-3.4572
E-1Ø1 Wall	-	53ØØ.Ø	-9.667Ø
5-1.5-12Ø Bend	7BØ1T	53Ø6.5	-9.8297
Profile Wire Chamber	7WCØ1	5312.5	-9.98ØØ
Target	5T	5313.5	-1Ø.ØØ5Ø
5-1.5-12Ø Bend	5BØ1T	532Ø.5	-1Ø.2Ø83
Beam Dump	7DMP	5345.5	-1Ø.9343
3Q84 Quad	5DØ1-1	5385.5	-12.Ø959
3Q84 Quad	5DØ1-2	5394.Ø	-12.3427
3Q84 Quad	5DØ1-3	54Ø2.5	-12.5895
5-1.5-24Ø Bend	5WØ1-1	5417.5	-13.Ø1Ø9
3Q84 Quad	5FØ1-1	5432.5	-13.3754

TABLE I (Cont'd)

N7/N5 MODIFICATIONS FOR E100, E101, E103

Element	Position Code	Z(FT) Cent	X(FT) Cent
3Q84 Quad	5FØ1-2	5441.Ø	-13.5739
5-1.5-24Ø Bend	5WØ1-2	5456.Ø	-13.91ØØ
4-4-3Ø Vert. Vernier	5VØ1	5469.Ø	-14.1539
E-1Ø1 Wall	-	5472.Ø	-14.2Ø69
E-1Ø3 Wall	-	6Ø43.Ø	-24.2959
Profile Wire Chamber	3WCØ3 H,V	6Ø44.Ø	-24.3136
3Q84 Quad	5DØ3	6Ø49.5	-24.41Ø8
1Ø' Coll. Horiz.	5CØ3H	6Ø62.Ø	-24.41Ø8
5-1.5-12Ø Bend	5EØ3-1	6Ø73.5	-24.8381
5-1.5-12Ø Bend	5EØ3-2	6Ø55.Ø	-25.Ø717
5-1.5-12Ø Bend	5EØ3-3	6Ø96.5	-25.3358
5-1.5-12Ø Bend	5EØ3-4	61Ø8.Ø	-25.63Ø3
5-1.5-12Ø Bend	5EØ3-5	6119.5	-25.9552
4-4-3Ø Vert. Vernier	5VØ3	6127.5	-26.1991
E-1Ø3 Wall	-	6132.Ø	-26.3382

TABLE II

BEND POINTS PRIMARY BEAM

Location	Position Code	Z(FT)	X(FT)	θ(MR)	θ(Total-MR)
E-100	7E00	4989.25	-1.886	-25.04	-25.04
		SECONDARY BEAM			
E-101	5T	5313.50	-10.005	-4.00	-29.04
E-101	5W01	5436.75	-13.584	11.37	-17.67
E-103	5E03	6096.50	-25.241	-13.23	-30.90
E-105	5W05$_1$	6546.35	-39.140	+11.00	-19.90
E-105	5W05$_2$	6608.30	-40.240	+16.50	-3.40
E-109	5W09$_1$	7134.75	-42.160	+33.00	+29.60
E-109	5W09$_2$	7240.08	-39.911	+16.50	+46.10

BEND CURRENTS FOR 400 GeV

Magnets	Position Code	Field (KG)	Current (AMPS)
5-1.5-240	7E00	13.70	3547.3
5-1.5-240	5W01	12.44	3221.7
5-1.5-120	5E03*	11.58	1094.7
Mixes of 5-1.5-240	5W05	12.04	3116.7
and 4-2-240	5W09	12.04	3116.7

*NOTE: For N3 line operation these values are 14.21 kg and 1342.9 Amps.

TABLE III

QUAD TUNE FOR 400 GeV PRIMARY

Magnets	Position Code	Field Gradient (Kg/in)	Current (Amps)
3Q120	7D00	-1.95	41.3
3Q120	7F00	2.64	56.1
	QUAD TUNE* FOR 400 GeV SECONDARY		
3Q84	5D01	-4.45	3246.7
3Q84	5F01	4.53	3304.6
3Q84	5D03	-1.60	1166.6
3Q84	5F05	4.21	3067.8
3Q84	5D05	-4.09	2980.0
3Q84	5D06	-0.70	149.6
4Q120	5F09	4.92	3583.8
3Q84	5D09	-3.66	2669.4
3Q52	5D13	-4.91	3582.3
3Q84	5F13**	6.35	4630.0

*NOTE: Several of these quadrupoles have polarities which are different from the existing beam line.

**NOTE: One magnet at this location provides only partial focussing in Lab E for beam momenta above 330 GeV. (This is also true with the existing beamline.)

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HISTOGRAM NO  4
HORIZONTAL AXIS    X↑ IN MR                              0.000 FT    FROM THE TARGET
VERTICAL AXIS      Y↑ IN MR                              0.000 FT    FROM THE TARGET, FLAG AT       2592.495 FT

                           -2.000     -1.000      0.000      1.000      2.000 TOTALS
                           I**---**---**---**---**---**---**---**---**I--------
 -2.000 TO  -1.900  I                                          I        0
 -1.900 TO  -1.800  I                                          I        0
 -1.800 TO  -1.700  I                                          I        0
 -1.700 TO  -1.600  I                                          I        0
 -1.600 TO  -1.500  I                                          I        0
 -1.500 TO  -1.400  I                                          I        0
 -1.400 TO  -1.300  I                                          I        0
 -1.300 TO  -1.200  I                                          I        0
 -1.200 TO  -1.100  I                                          I        0
 -1.100 TO  -1.000  I                                          I        0
 -1.000 TO   -.900  I              233431251                   I       24
  -.900 TO   -.800  I            2A3CDHJDSDB4                  I      145
  -.800 TO   -.700  I           87KLE8HHIDMJE5                 I      203
  -.700 TO   -.600  I          7CIHENJKTHLPGPGA                I      289
  -.600 TO   -.500  I         2GKFKOLPLVQJRMMAE5               I      340
  -.500 TO   -.400  I        1FJBGRLOMMXJKNNJNCG               I      362
  -.400 TO   -.300  I        5AELRFVMOR$YP$VVHLC6              I      448
  -.300 TO   -.200  I        5LNIIXMMV$SX$OMXGRGA              I      465
  -.200 TO   -.100  I        4DFLJTUPQ$PVL$UNVHD6              I      452
  -.100 TO    .000  I        FASONKXTPTR$O$UTSMC6              I      494
   .000 TO    .100  I        CIKNQQVXY$M$UUS$SRT2              I      525
   .100 TO    .200  I        AKJVWMMO$V $$$SQWH-55             I      500
   .200 TO    .300  I        5HJLSMSRWRTURYORUCK7              I      466
   .300 TO    .400  I        7IGEMLTNRRW$RUPQSLH6              I      456
   .400 TO    .500  I         GGNGPOINOTXSQPSHV71              I      402
   .500 TO    .600  I          4FDFIKNLHVMKJHDG84              I      299
   .600 TO    .700  I           8IHDCETIGPGHOIF8               I      271
   .700 TO    .800  I            98CHAGGJJGIDF7                I      195
   .800 TO    .900  I             3GFBLBELD96A                 I      150
   .900 TO   1.000  I               15514312                   I       23
  1.000 TO   1.100  I                                          I        0
  1.100 TO   1.200  I                                          I        0
  1.200 TO   1.300  I                                          I        0
  1.300 TO   1.400  I                                          I        0
  1.400 TO   1.500  I                                          I        0
  1.500 TO   1.600  I                                          I        0
  1.600 TO   1.700  I                                          I        0
  1.700 TO   1.800  I                                          I        0
  1.800 TO   1.900  I                                          I        0
  1.900 TO   2.000  I                                          I        0
                    I**---**---**---**---**---**---**---**---**I--------
                    I                                          I
                    I                                          I
                    I          12233434444544434321            I
                    I         65381608438036910254             I
           TOTALS   I 0000000000548726043913053044290000000000 I     6509

  TOTAL NUMBER OF ENTRIES =         6509 INCLUDING UNDERFLOW AND OVERFLOW AS FOLLOWS

                         UNDERFLOW      OVERFLOW
              ACROSS         0              0
              DOWN           0              0
```

FIGURE 1
Solid Angle Acceptance for Proposed Design


```
HISTOGRAM NO  4
HORIZONTAL AXIS    X↑ IN MR                              0.000 FT    FROM THE TARGET
                                                         0.000 FT    FROM THE TARGET, FLAG AT       2592.495 F
```

```
HISTOGRAM NO  1
HORIZONTAL AXIS     X↑ IN MR                              0.000 FT    FROM THE TARGET
VERTICAL AXIS       Y↑ IN MR                              0.000 FT    FROM THE TARGET, FLAG AT       2965.995 FT

                      -2.000      -1.000      0.000       1.000       2.000  TOTALS
                      I**---**---**---**---**---**---**---**---**I--------
 -2.000  TO   -1.900  I                                          I       0
 -1.900  TO   -1.800  I                                          I       0
 -1.800  TO   -1.700  I                                          I       0
 -1.700  TO   -1.600  I                                          I       0
 -1.600  TO   -1.500  I                                          I       0
 -1.500  TO   -1.400  I                                          I       0
 -1.400  TO   -1.300  I                                          I       0
 -1.300  TO   -1.200  I                                          I       0
 -1.200  TO   -1.100  I                                          I       0
 -1.100  TO   -1.000  I                                          I       0
 -1.000  TO    -.900  I                  5OHXHKF91               I     141
  -.900  TO    -.800  I                 8OITY$$R$WV6             I     333
  -.800  TO    -.700  I                7H$VTMTTZS7VS6            I     364
  -.700  TO    -.600  I                A$POTXV$MU$R$C            I     399
  -.600  TO    -.500  I                AMUXUWQ$ZR$MQ8            I     383
  -.500  TO    -.400  I                5NZRUUS$PPTSOD            I     358
  -.400  TO    -.300  I                6ROZRST$$U$$W8            I     404
  -.300  TO    -.200  I                AJYSOX$TZ$POT6            I     375
  -.200  TO    -.100  I                6MWSRS$PWL$WJC            I     359
  -.100  TO     .000  I                6QO$YPTR$P$SS7            I     379
   .000  TO     .100  I                8TVVYZ$M$VUO$B            I     410
   .100  TO     .200  I                D$OMQ$V$$$WQT8            I     398
   .200  TO     .300  I                AWSTWWRTWU$NNC            I     376
   .300  TO     .400  I                AUMYSXSZ$UXUUF            I     400
   .400  TO     .500  I                DJPRNPSY$Z$SR6            I     363
   .500  TO     .600  I                5LWYWZP$QVXOK7            I     367
   .600  TO     .700  I                7NNRR$$VZKSYMD            I     362
   .700  TO     .800  I                1LQWSWVWRTVNN7            I     343
   .800  TO     .900  I                 6S$O$LT$STEF             I     307
   .900  TO    1.000  I                  25LKPVSD5               I     150
  1.000  TO    1.100  I                                          I       0
  1.100  TO    1.200  I                                          I       0
  1.200  TO    1.300  I                                          I       0
  1.300  TO    1.400  I                                          I       0
  1.400  TO    1.500  I                                          I       0
  1.500  TO    1.600  I                                          I       0
  1.600  TO    1.700  I                                          I       0
  1.700  TO    1.800  I                                          I       0
  1.800  TO    1.900  I                                          I       0
  1.900  TO    2.000  I                                          I       0
                      I**---**---**---**---**---**---**---**---**I--------
                      I                                          I
                      I                                          I
                      I                14555666656441            I
                      I                21045004572955            I
            TOTALS    I 0000000000000788787490900310000000000000 I    6961

     TOTAL NUMBER OF ENTRIES =          6961 INCLUDING UNDERFLOW AND OVERFLOW AS FOLLOWS

                               UNDERFLOW         OVERFLOW
                     ACROSS        0                0
                     DOWN          0                0
```

Figure 2
Solid Angle Acceptance for Existing Design

```
HISTOGRAM NO  1
HORIZONTAL AXIS     X↑ IN MR                              0.000 FT    FROM THE TARGET
```

```
HISTOGRAM NO 16
HORIZONTAL AXIS     X↑ IN MR                     2166.600 FT    FROM THE TARGET
VERTICAL AXIS       Y↑ IN MR                     2165.600 FT    FROM THE TARGET

                    -.400     -.200     -.000      .200      .400 TOTALS
                    I**---**---**---**---**---**---**---**---**I--------
 -.200 TO   -.190   I                                          I      0
 -.190 TO   -.180   I                                          I      0
 -.180 TO   -.170   I                                          I      0
 -.170 TO   -.160   I                                          I      0
 -.160 TO   -.150   I                                          I      0
 -.150 TO   -.140   I                                          I      0
 -.140 TO   -.130   I                                          I      0
 -.130 TO   -.120   I                                          I      0
 -.120 TO   -.110   I                                          I      0
 -.110 TO   -.100   I                                          I      0
 -.100 TO   -.090   I                                          I      0
 -.090 TO   -.080   I                                          I      0
 -.080 TO   -.070   I                                          I      0
 -.070 TO   -.060   I                                          I      0
 -.060 TO   -.050   I                                          I      0
 -.050 TO   -.040   I                                          I      0
 -.040 TO   -.030   I           31466FHTMB965                  I    134
 -.030 TO   -.020   I         1 2FR$$$$$$$$T841                I    597
 -.020 TO   -.010   I          49HR$$$$$$$$$QA6                I   1093
 -.010 TO    .000   I         119U$$$$$$$$$$$E31               I   1390
  .000 TO    .010   I        117DF$$$$$$$$$$KM3                I   1335
  .010 TO    .020   I         23BKZ$$$$$$$$$$A2                I   1102
  .020 TO    .030   I           8DEQ$$$$$$$TB1                 I    590
  .030 TO    .040   I            24288COGA8441                 I    103
  .040 TO    .050   I                                          I      0
  .050 TO    .060   I                                          I      0
  .060 TO    .070   I                                          I      0
  .070 TO    .080   I                                          I      0
  .080 TO    .090   I                                          I      0
  .090 TO    .100   I                                          I      0
  .100 TO    .110   I                                          I      0
  .110 TO    .120   I                                          I      0
  .120 TO    .130   I                                          I      0
  .130 TO    .140   I                                          I      0
  .140 TO    .150   I                                          I      0
  .150 TO    .160   I                                          I      0
  .160 TO    .170   I                                          I      0
  .170 TO    .180   I                                          I      0
  .180 TO    .190   I                                          I      0
  .190 TO    .200   I                                          I      0
                    I**---**---**---**---**---**---**---**---**I--------
                    I                                          I
                    I                                          I
                    I            113468998631                  I
                    I          1519000987502461                I
          TOTALS    I 0000000001557344000643464251000000000000 I   6544

 TOTAL NUMBER OF ENTRIES =        6544 INCLUDING UNDERFLOW AND OVERFLOW AS FOLLOWS

                              UNDERFLOW       OVERFLOW
                   ACROSS         0               0
                   DOWN           0               0
```

Figure 3
Beam Divergence in the Region
Containing Cherenkov Counters.

HISTOGRAM NO 16
HORIZONTAL AXIS   X↑ IN MR   2166.600 FT   FROM THE TARGET

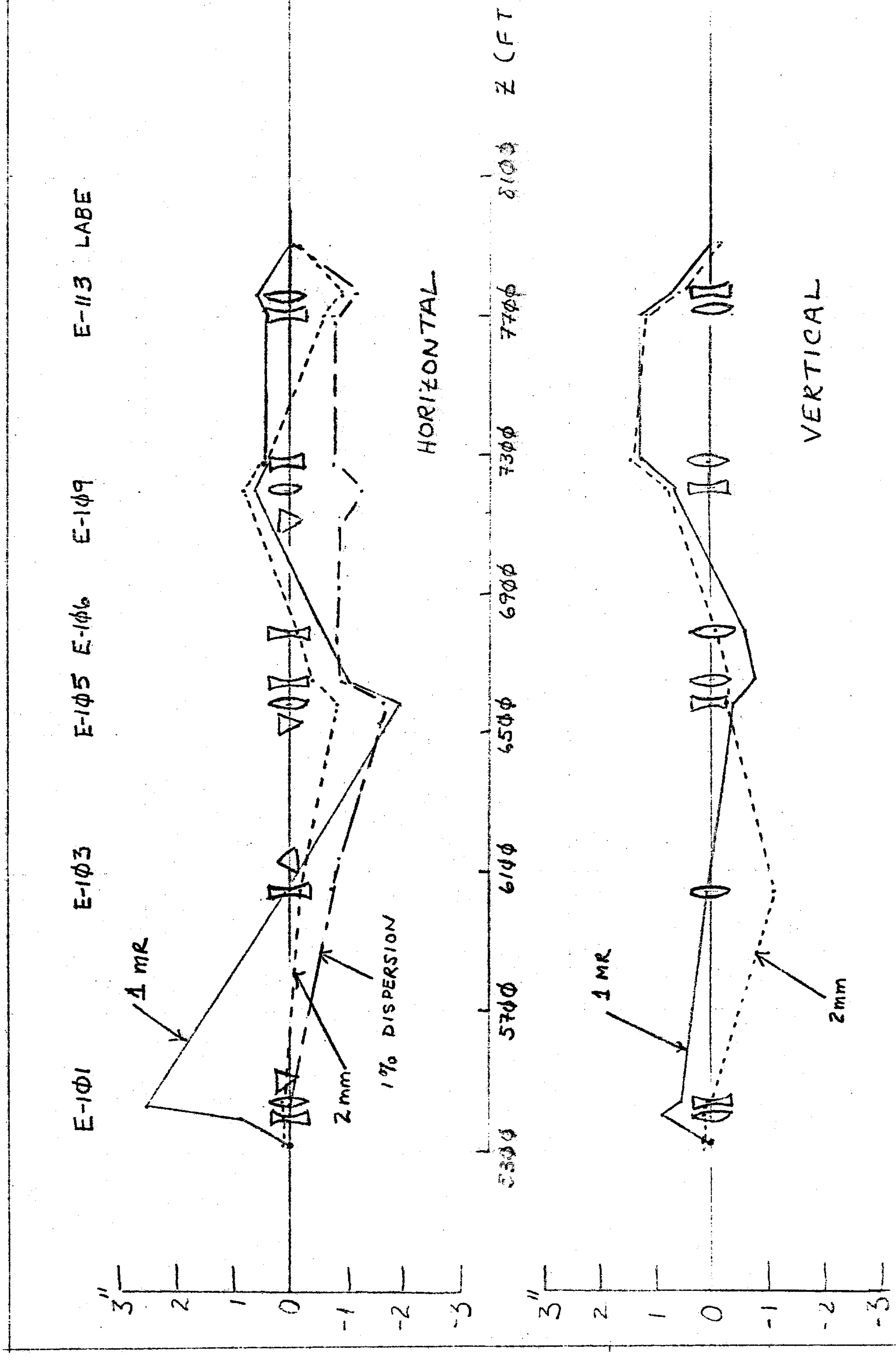

Figure 4
Trajectories of the Principal
Rays for the New Design

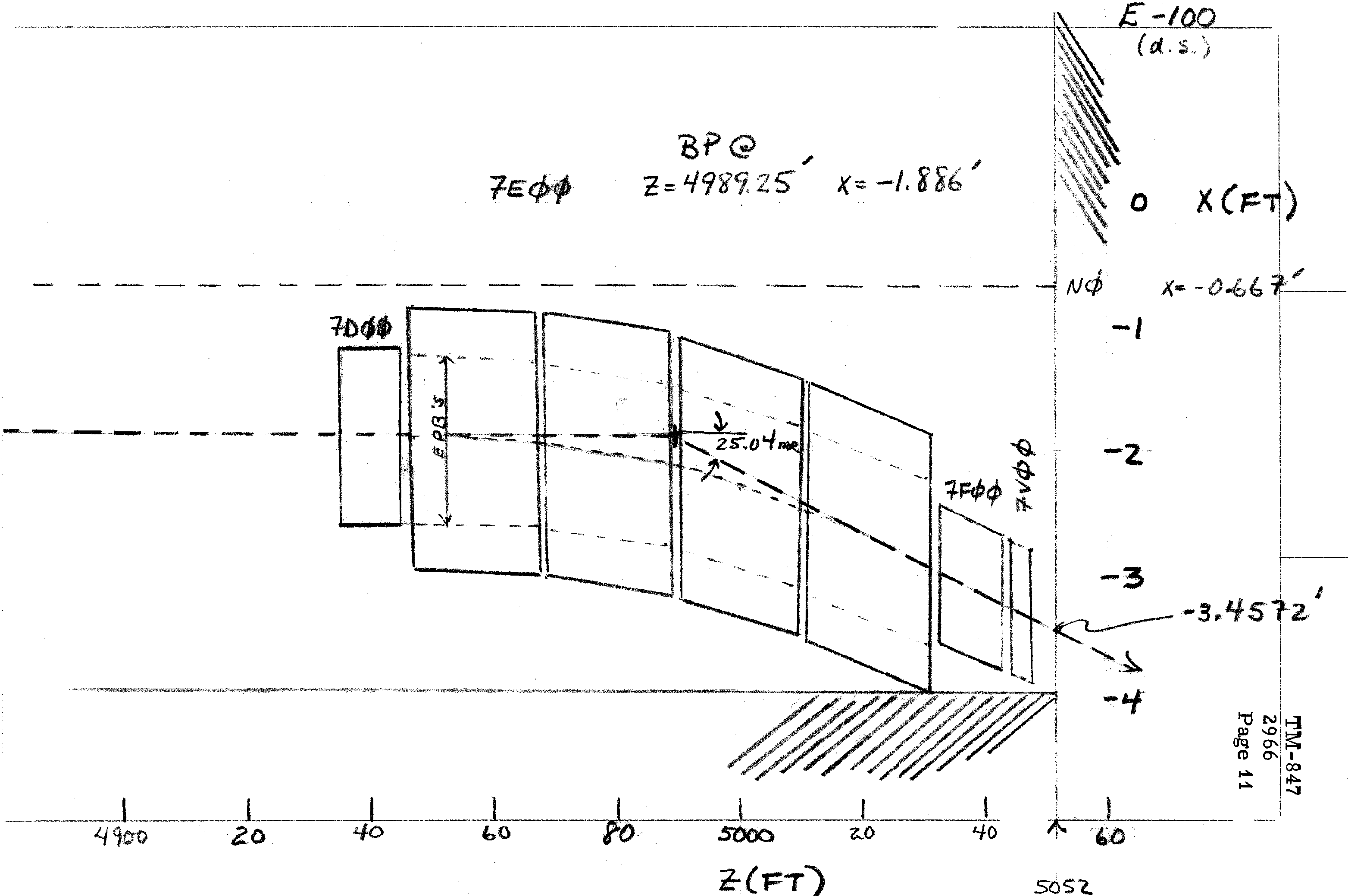

Figure 5
Proposed Modifications to E-100

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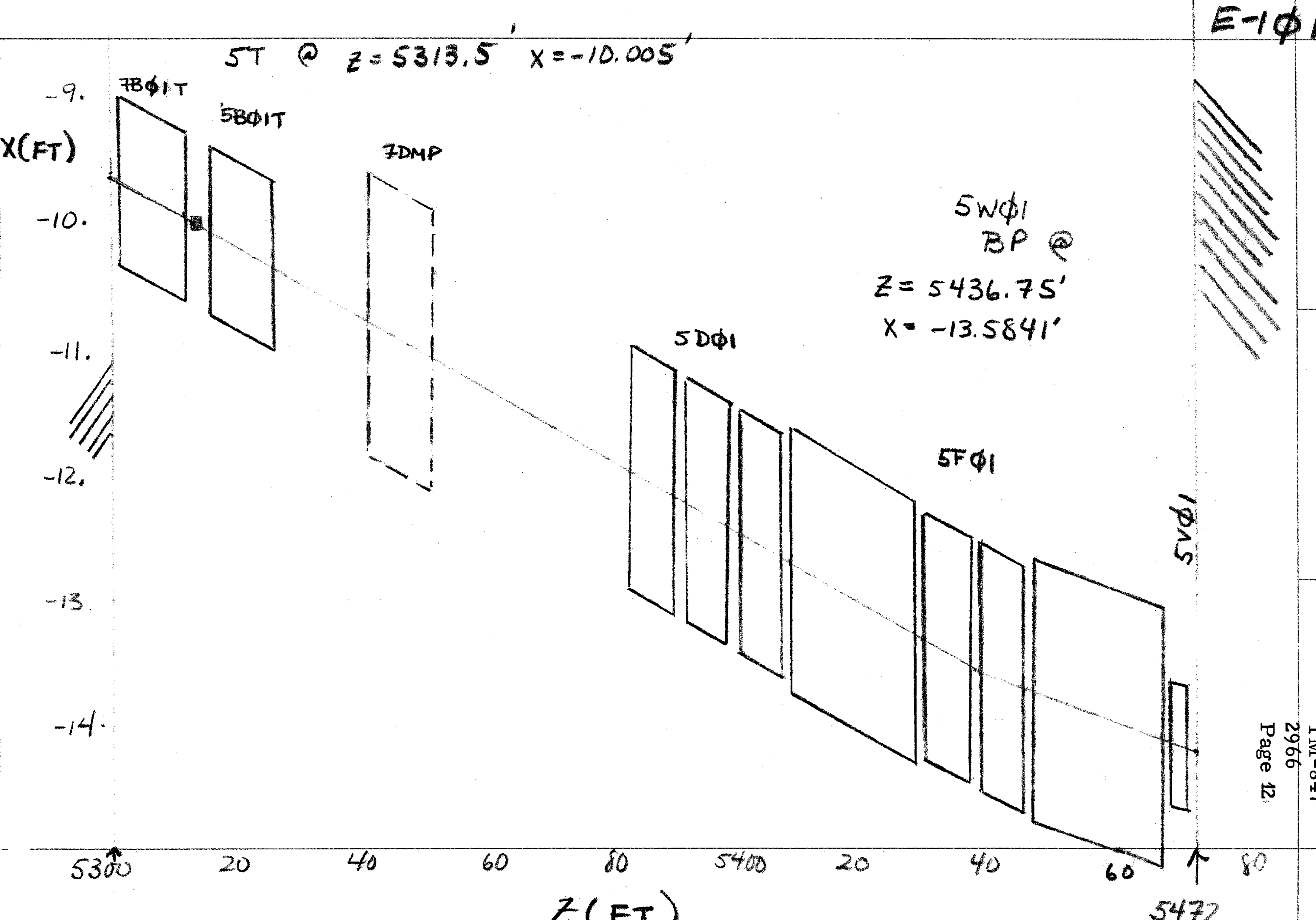

Figure 6
Proposed Modifications to E-1Ø1

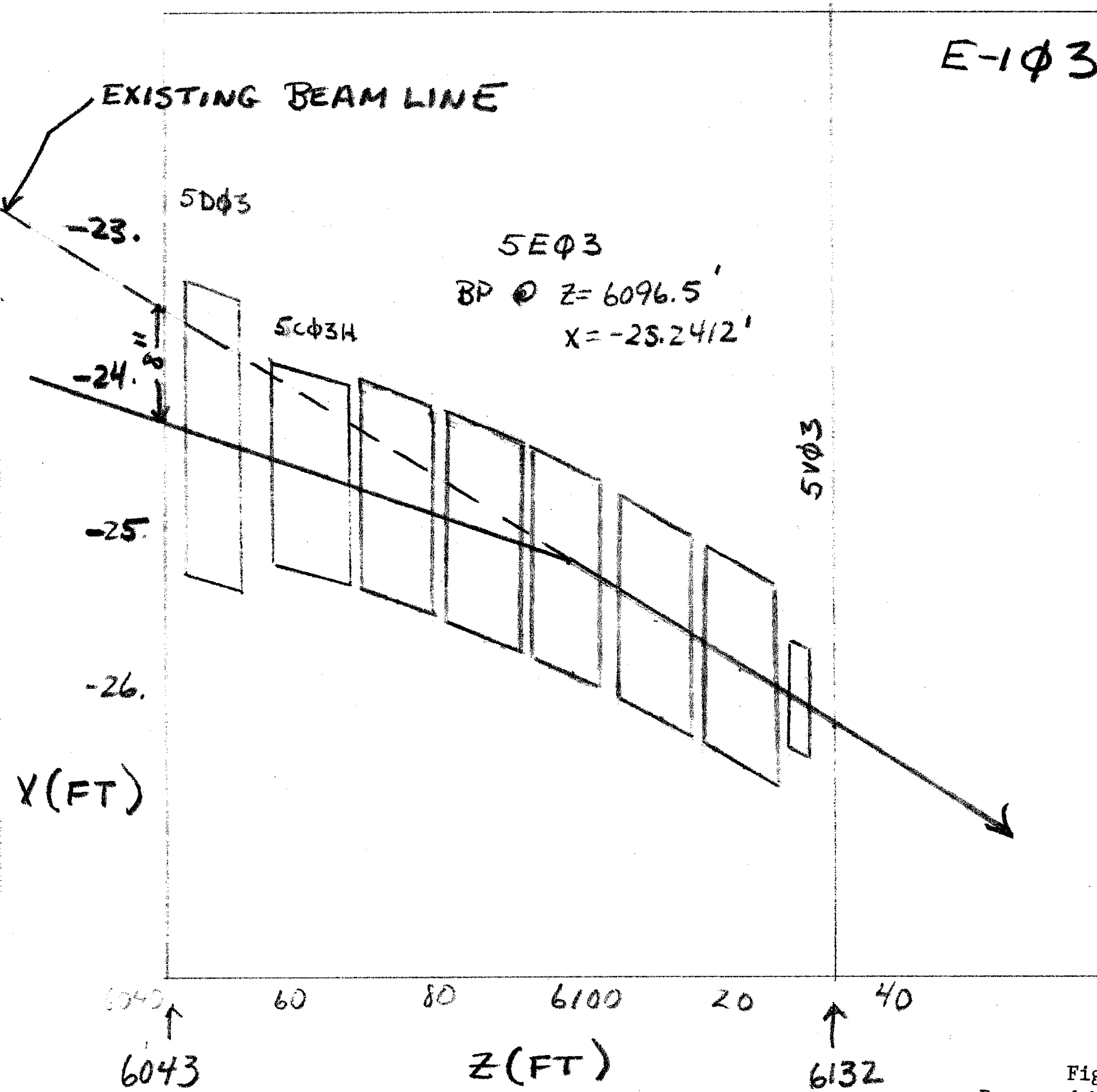

Figure 7
Proposed Modifications to E-1Ø3